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FANGS for BEAST

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FANGS: FE-I4 ATLAS Near Gamma Sensors

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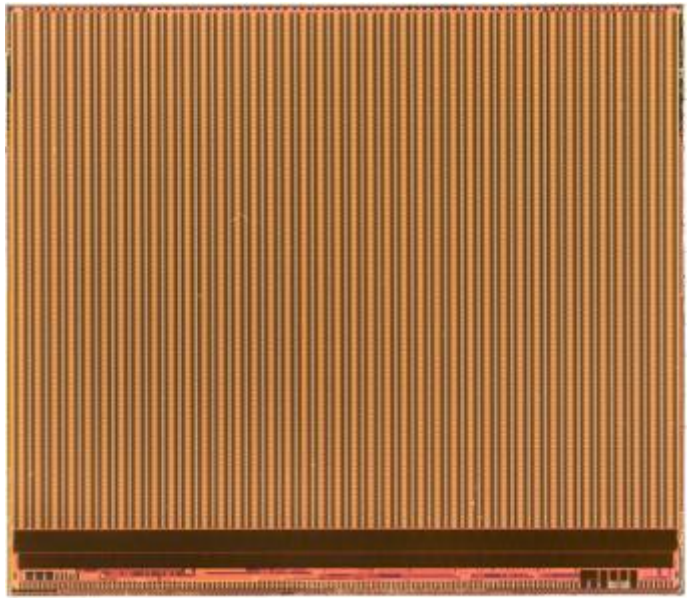
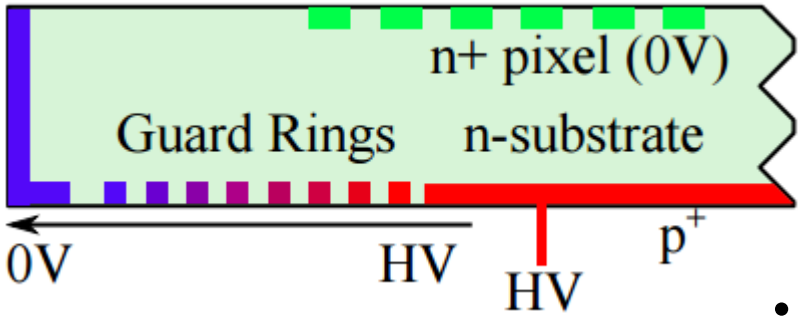


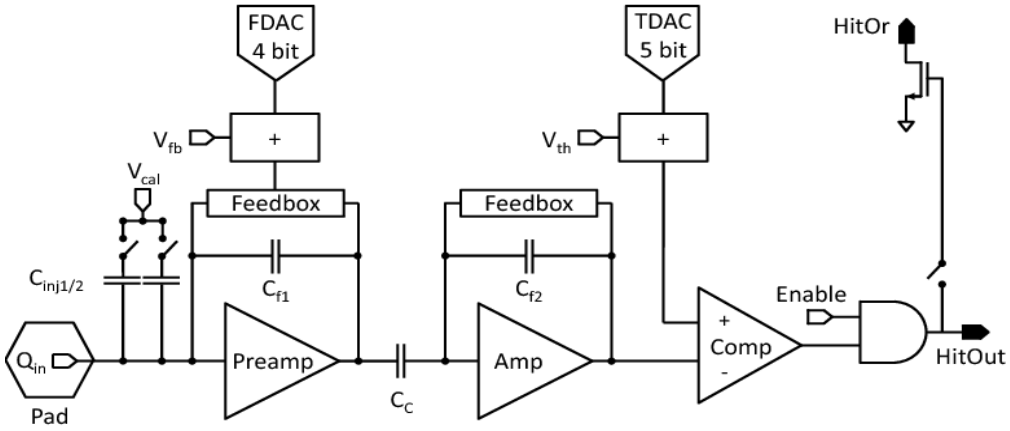


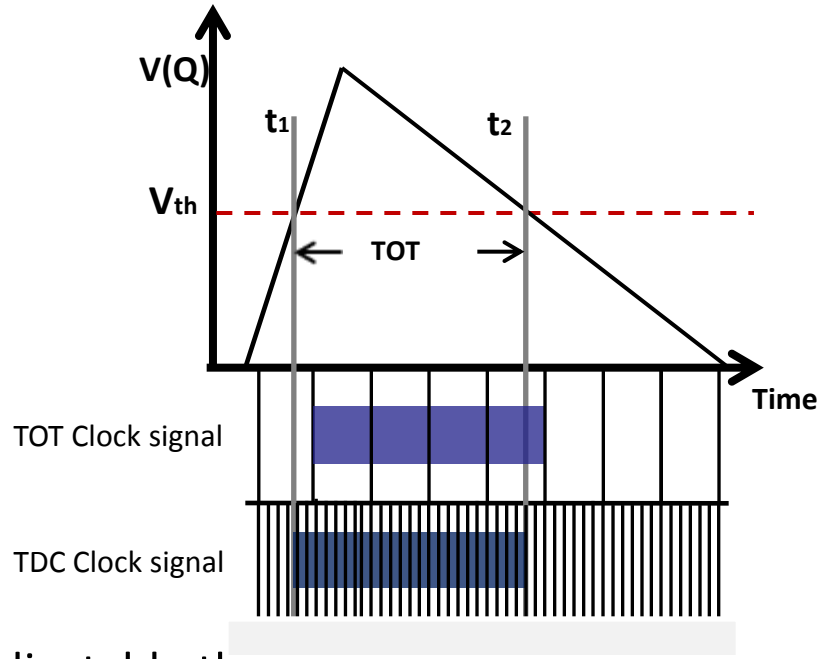
- FE-I4 read out chip
  High hit rates and radiation hard
  IBM 130 nm CMOS process
  Provides read out for 80x336 pixels
  Thickness=150 µm
  Physical size=**21x19 mm²**
  Bump bonded to Si sensor

- Sensor:
  n-in-n planar
  Pitch=**50x250 µm²**
  Thickness=200 µm
  Physical size=19x20 mm²
  HV=60 V
  Power=1.2 W

- Background radiation measurements in Phase 2:
  - Sensitive to low keV X-rays (6 keV to 60 keV)
  - Particle rates (25 ns)

TDC Method

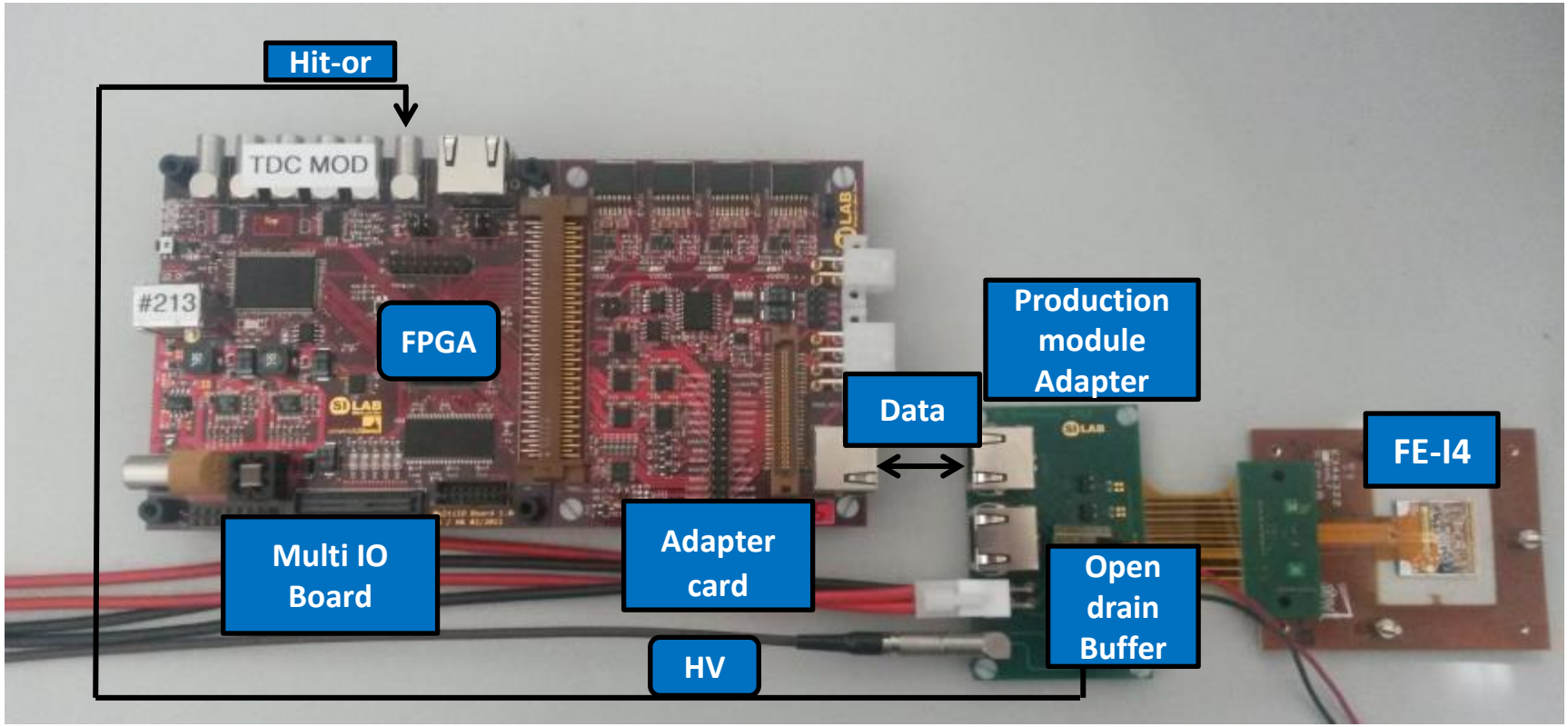




- Two stage amplifier → Discriminator with adjustable threshold.
- Time over threshold **(TOT)** with externally supplied 40 MHz clock.
- Time to digital converter **(TDC)** uses 640 MHz FPGA clock.
- Output of each pixel is ORed.
- Internal charge injection circuit for threshold tuning and calibration

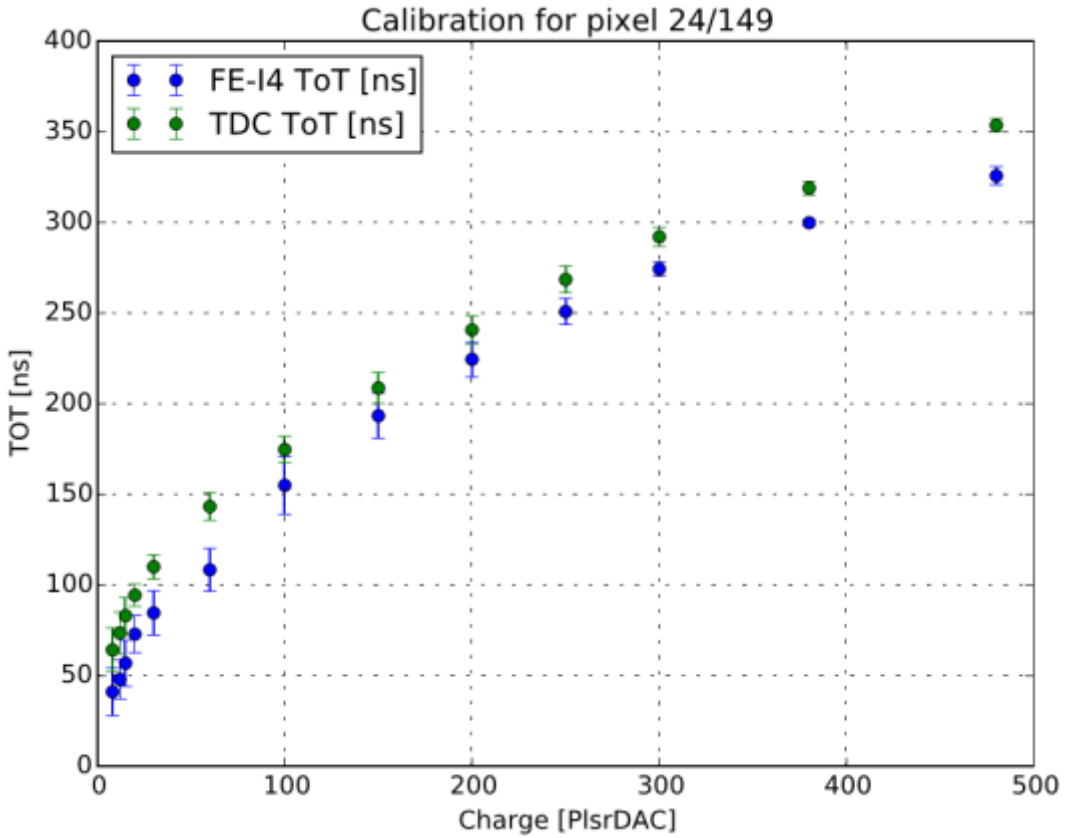
→ Both, high speed and adequate energy resolution achieved at the same time

Experimental Setup



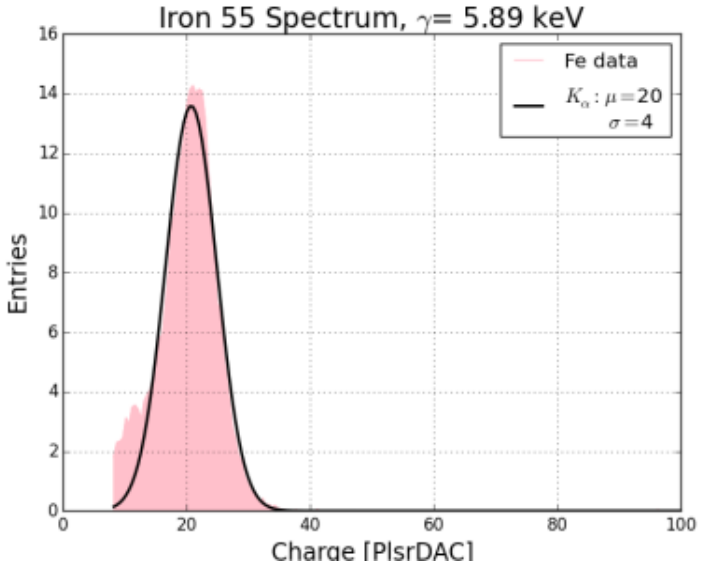
- USBpix used for readout and pyBAR for analysis.
- **Open drain buffer** amplifies HitOr signal on long cables (O(30 m)).
- New USBPix3 readout system being tested at the moment (8 FE at a time).
- Software allows to monitor multiple FE in parallel.

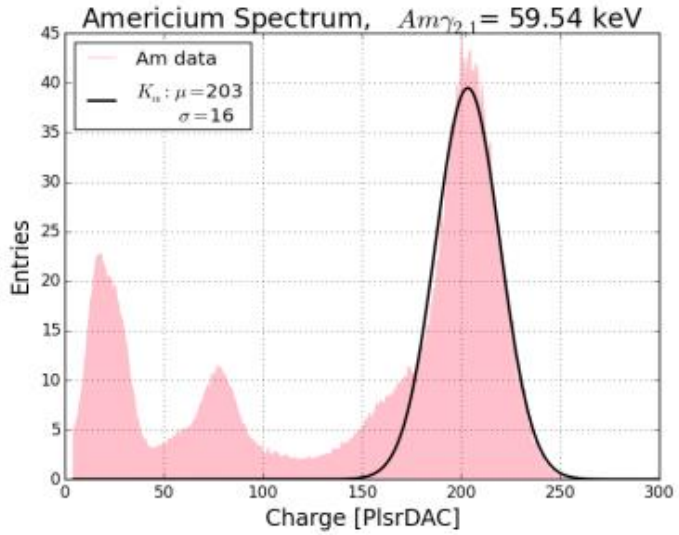
Pixel-per-pixel Calibration

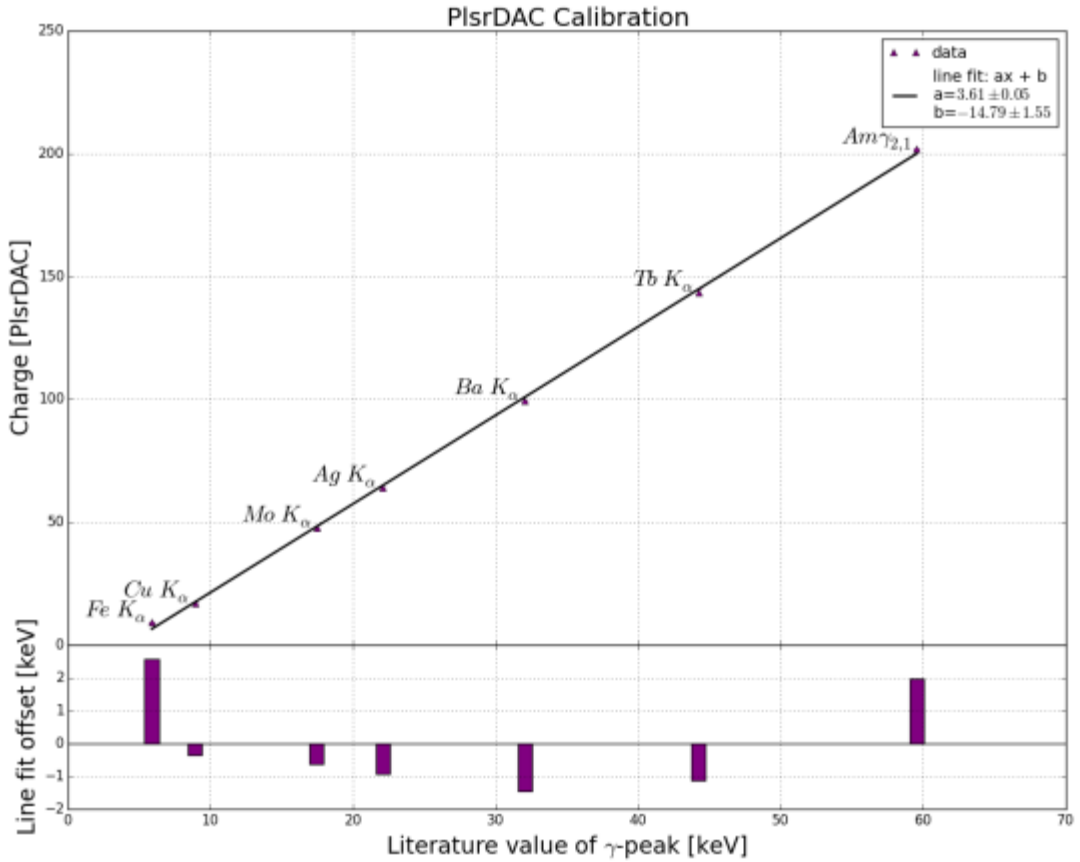


- Threshold tuning noise based
- Vth and TDC as a function of charge different for each pixel.
- Per pixel calibration needed.
- Internal charge injection in units of PlsrDAC ~ 55 electrons

Calibration and Dynamic Range

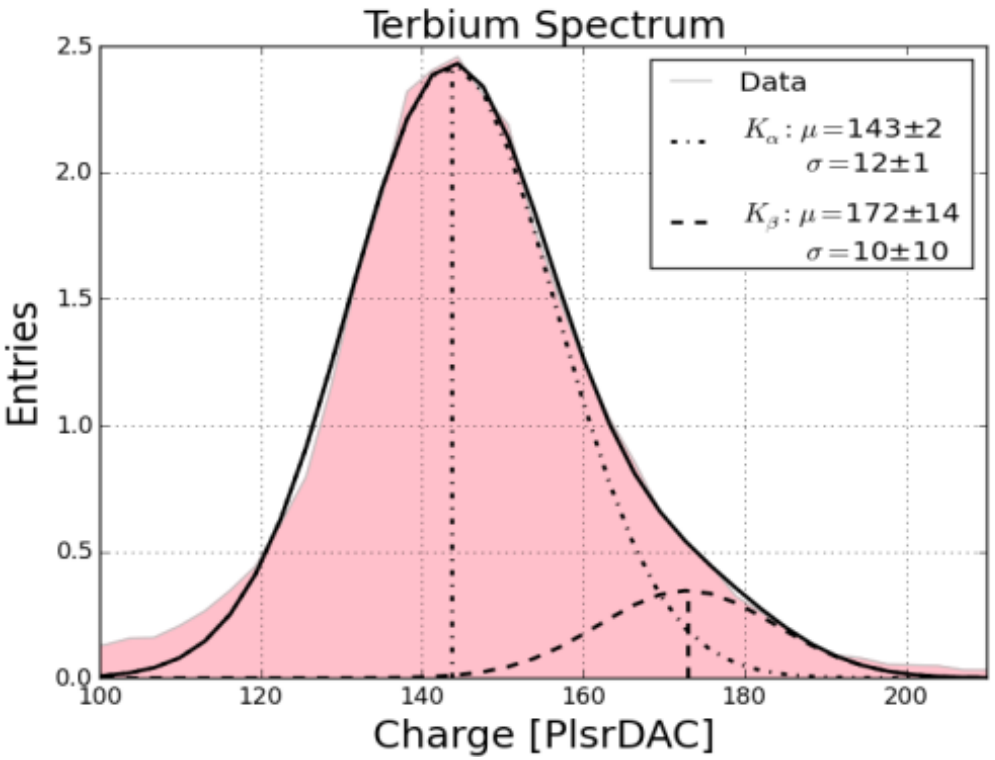




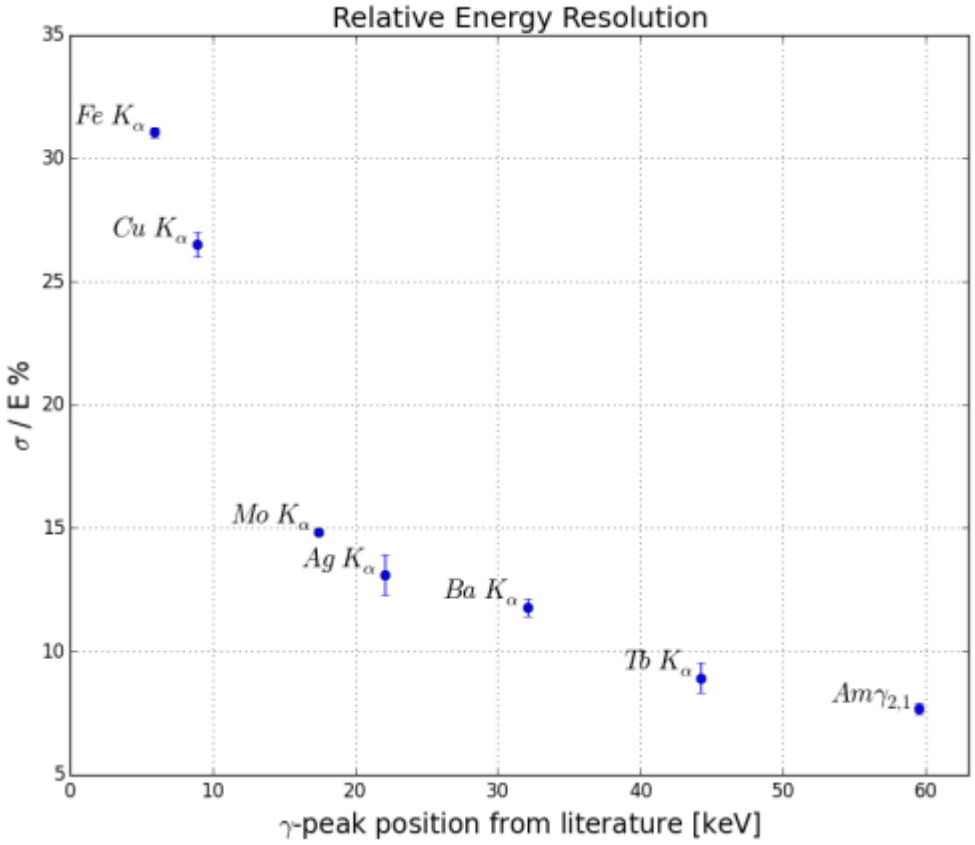


- Wide dynamic range covered (wider also possible)
- Lowest measured plsrDAC value ~ 7
  - Threshold of ~1000 electrons feasible

Energy Resolution

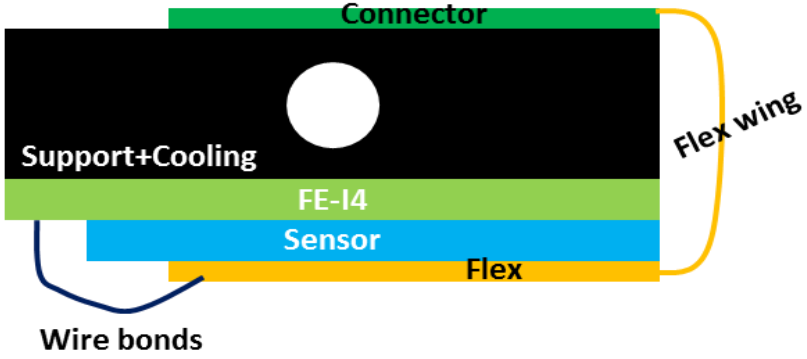


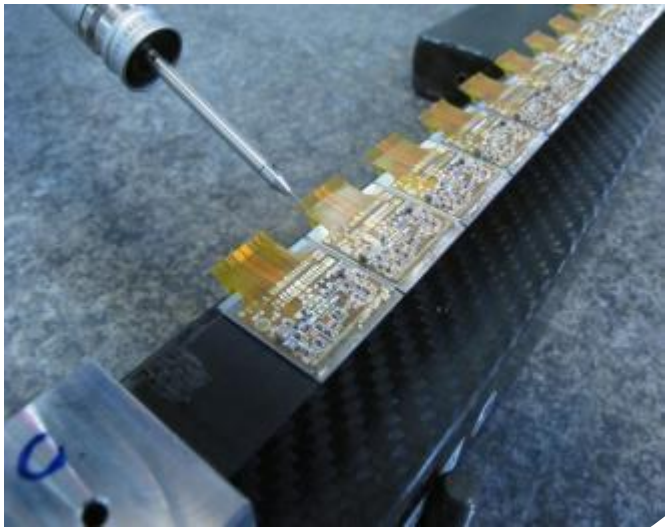
- Terbium Kα=44.23keV, Kβ =50.65 keV
- ΔE = 6.42 keV



- Adequate energy resolution
- Better than 15 % above 10 keV

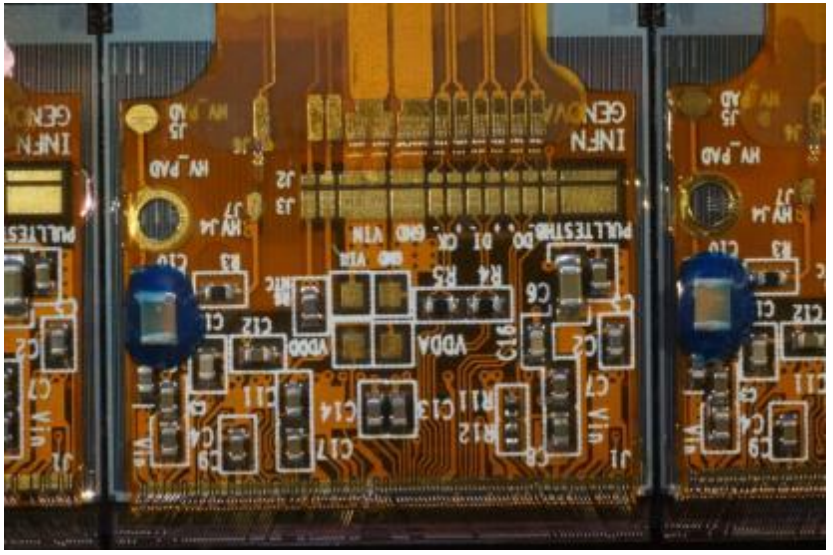
Initial Design Concept for Beast II

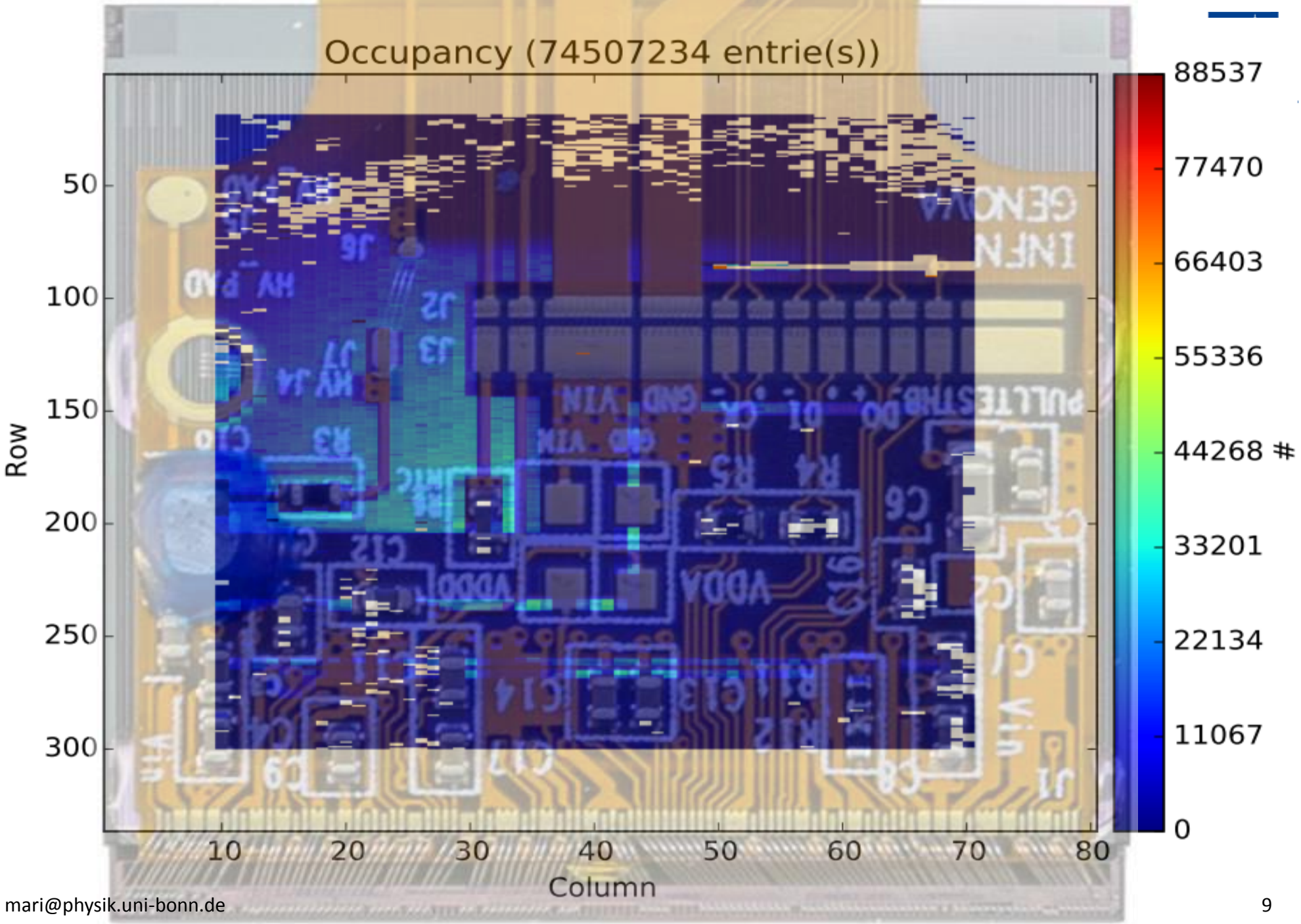




- Stave structure similar to ATLAS IBL.
- 90 µm thick flex attached on top of sensor for read out.

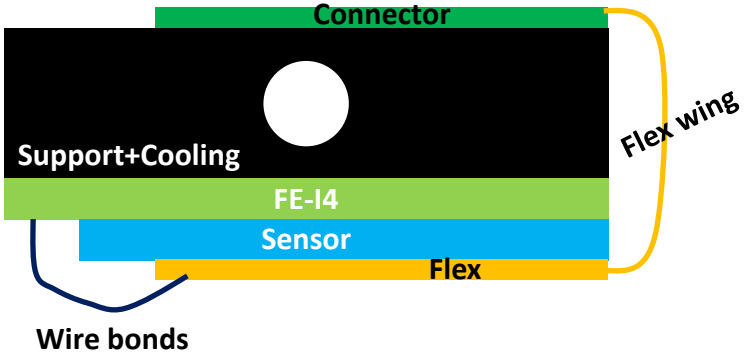
↘ BUT: High absorption probability in the low keV range → Forced a design change



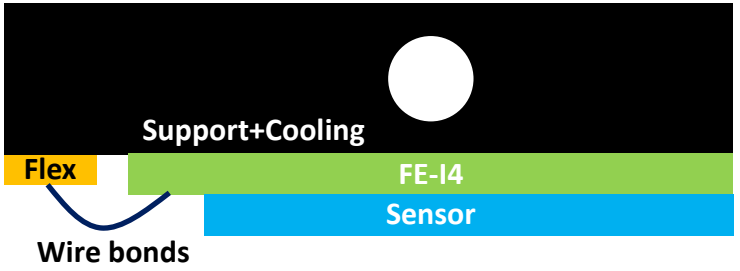

Occupancy (74507234 entrie(s))
Row
50
100
150
200
250
300
10
20
30
40
50
60
70
80
Column
88537
77470
66403
55336
44268 #
33201
22134
11067
0

FANGS Stave: Design Evolution

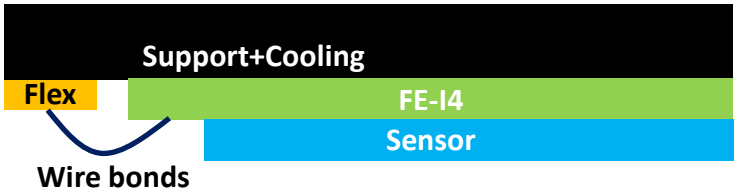
- How to mount few single chips in Phase 2?
  (Reusing existing infrastructure)



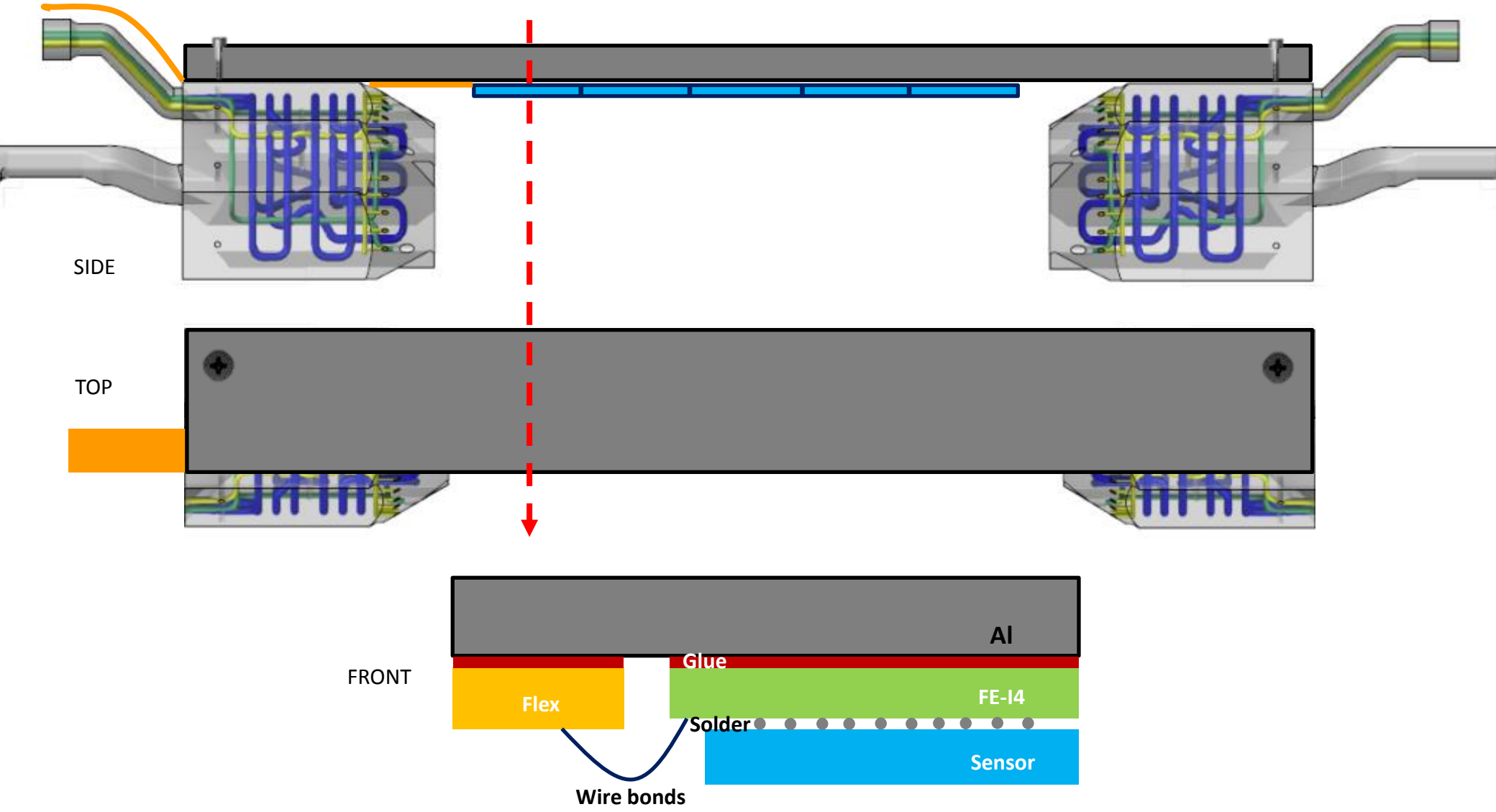
- Move the flex to one side. No material in front!



- Thinner support. Make use of PXD cooling



Mechanical Arrangement



FANGS and CLAWS Integration

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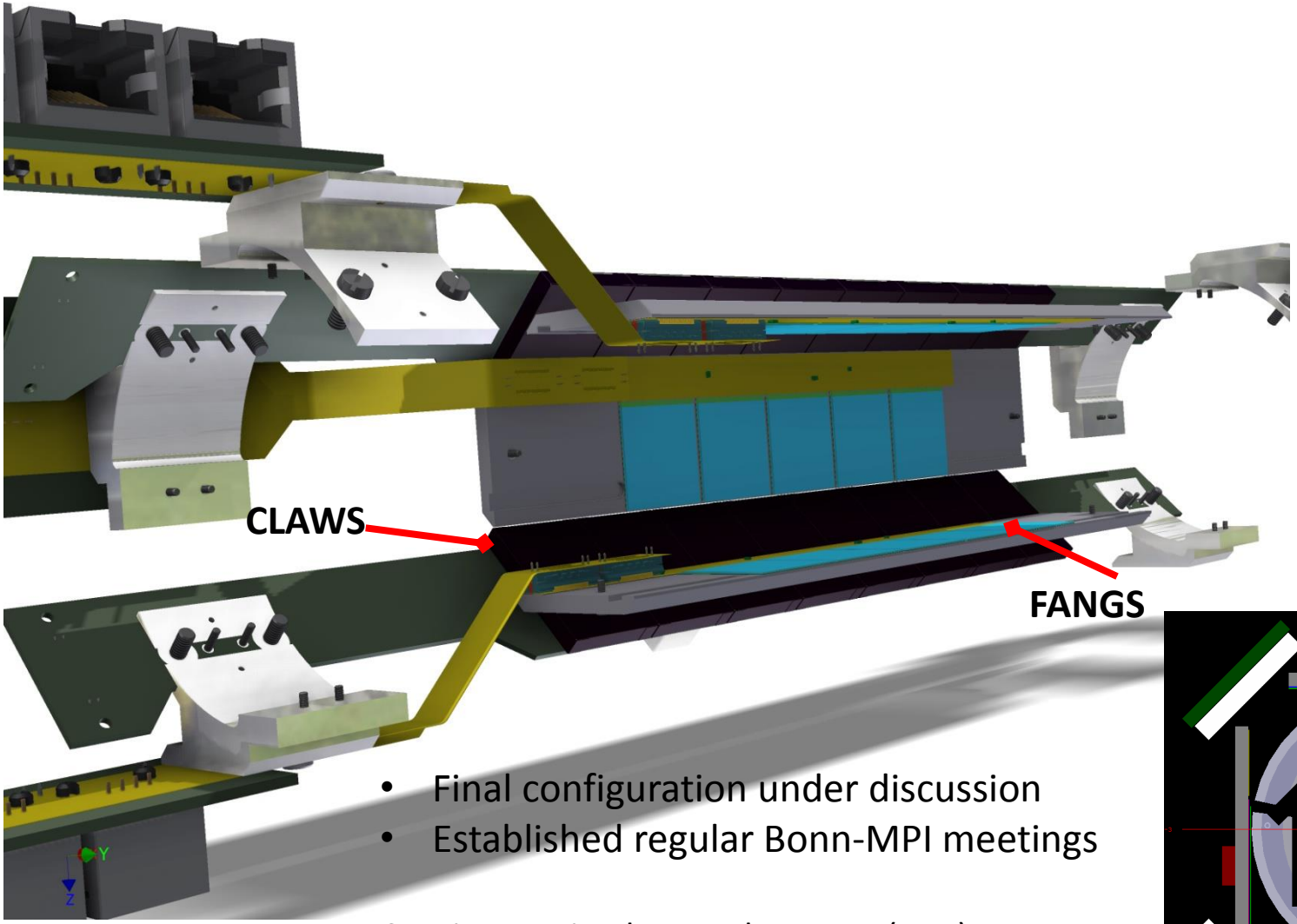
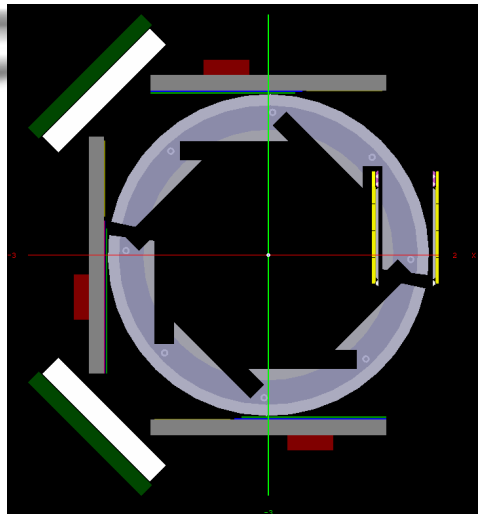


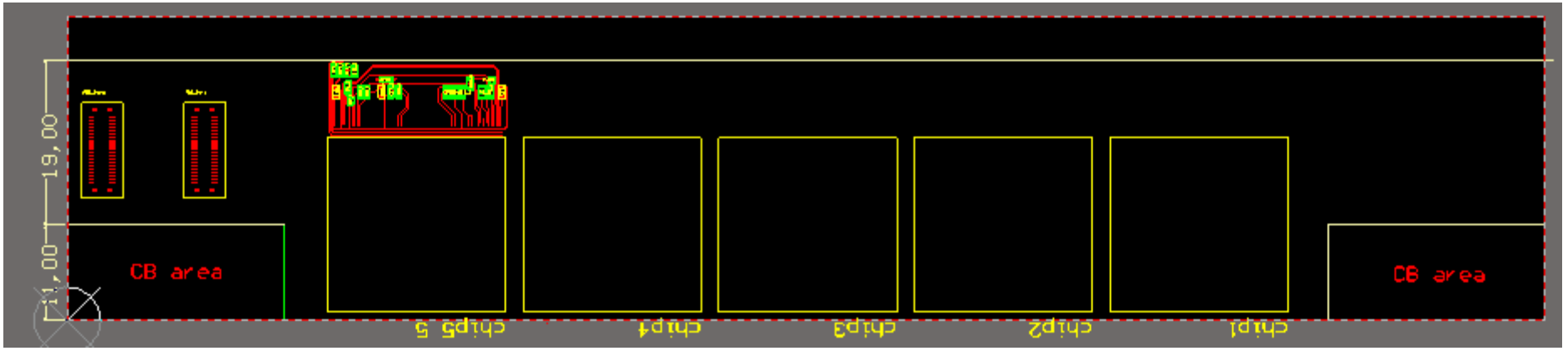
- Final configuration under discussion
- Established regular Bonn-MPI meetings

CAD integration by K. Ackermann (MPI)
BASF2 implementation M. Ritter (KEK-MPI)

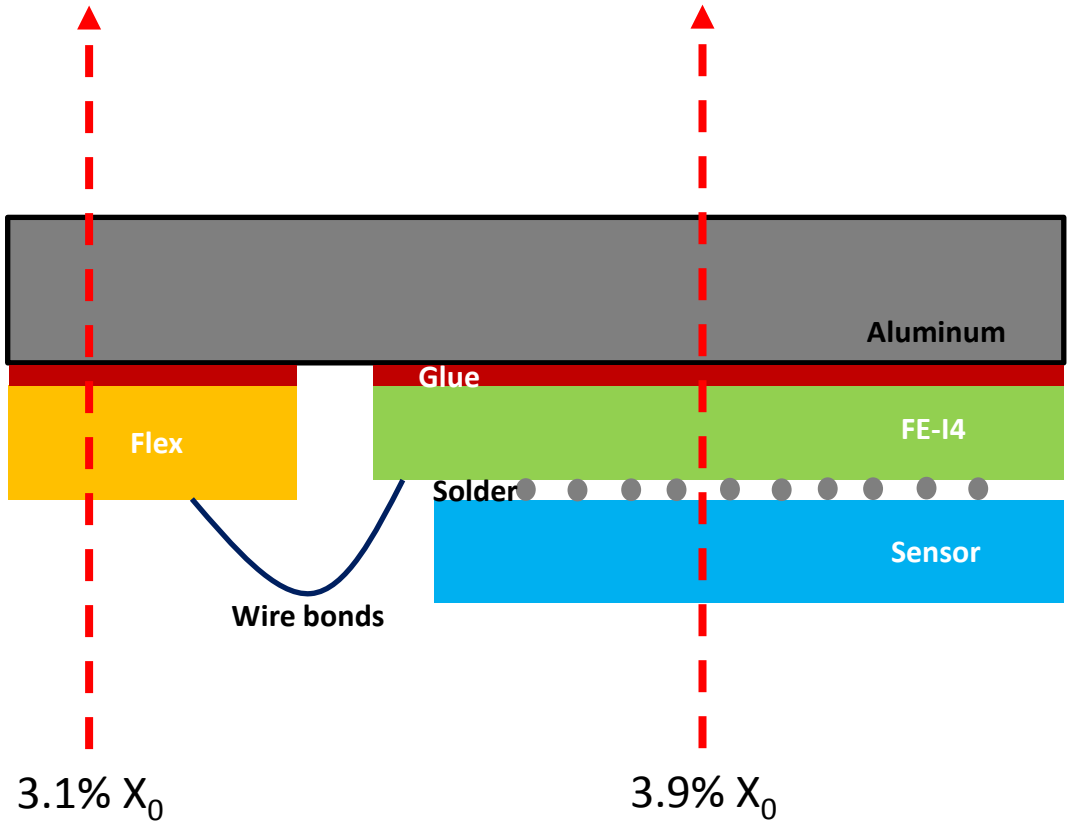


Flex Concept

- ❑ Design still evolving:
- 8 mm wide Kapton
- 2 x 40 pin connector on backward side
- Short intermediate Kapton connecting to a PCB attached to SVD ring
- 4 Ethernet and 1 power connectors on PCB



Aluminum Stave Material Budget



- Low and flat material budget distribution
- No impact in outer detectors

Reminder: PXD+SVD contribute with ~4.0% X_0

- Support:
3 mm thick Aluminum → 3.4%X_0

- Epoxy:
50 µm thick → 0.014%X_0

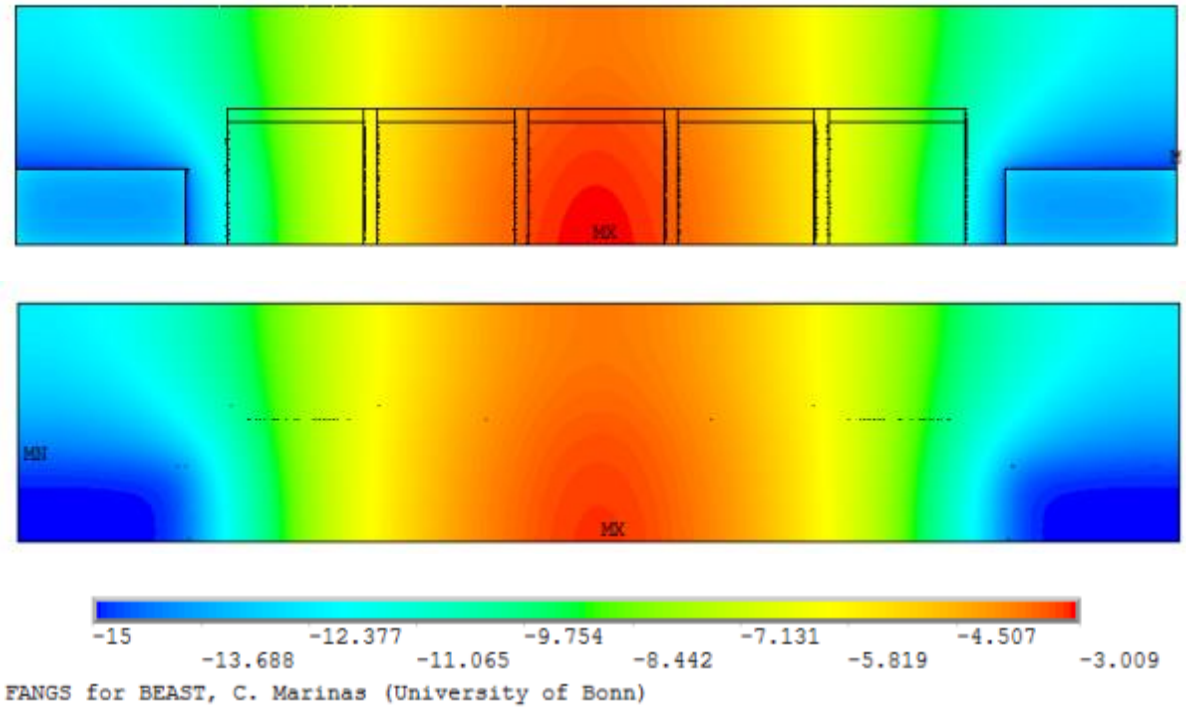
- FE-I4
150 µm thick → 0.16%X_0

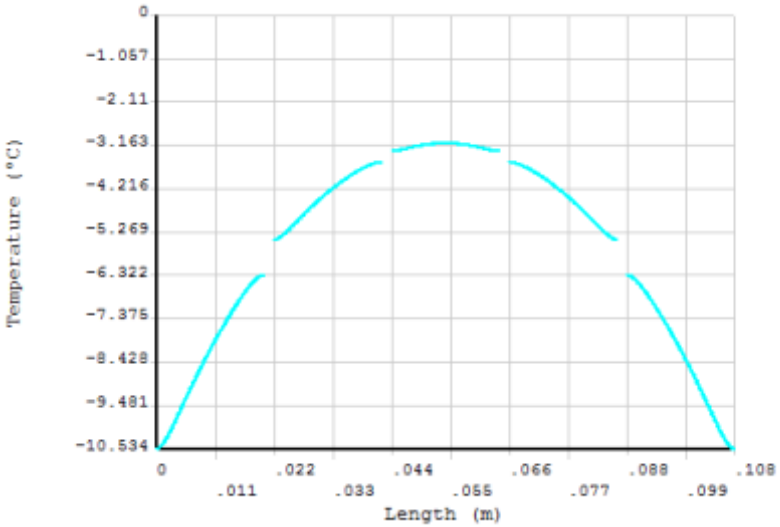
- Sensor:
200 µm thick → 0.21%X_0

- Solder balls
SnAg → 0.17%X_0 (3.3% of the area)

- Flex (or 500 µm PCB)
66 µm thick polymide → 0.023%X_0
24 µm Cu (2 layers) → 0.17%X_0

FEA of a FANGS (Al-based) Stave





- Maximum temperature = -4 ^{o}C
- Maximum ΔT within one sensor = 4 ^{o}C
- Power = 1.2 W each FE
- Cooling block = -15 ^{o}C
- Environment = 20 ^{o}C at 2 m/s

- Proper heat handling
- Low and flat temperature profile

Conclusion

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- FANGS is rapidly evolving into a final detector system for background (energy and rates) measurements at BEAST Phase 2
- All the aspects related to the design, characterization, integration are in good progress
- 30 hybrids (FE-I4 and planar sensor) have been prepared (twice what is needed)
- Front end has been **tuned to cover the expected energy range with proper resolution**
- **Multiple-FE DAQ** with long cables is being tested with a new readout system
- Kapton flex and intermediate boards are being designed
- Mechanical concept and cooling management are well in progress

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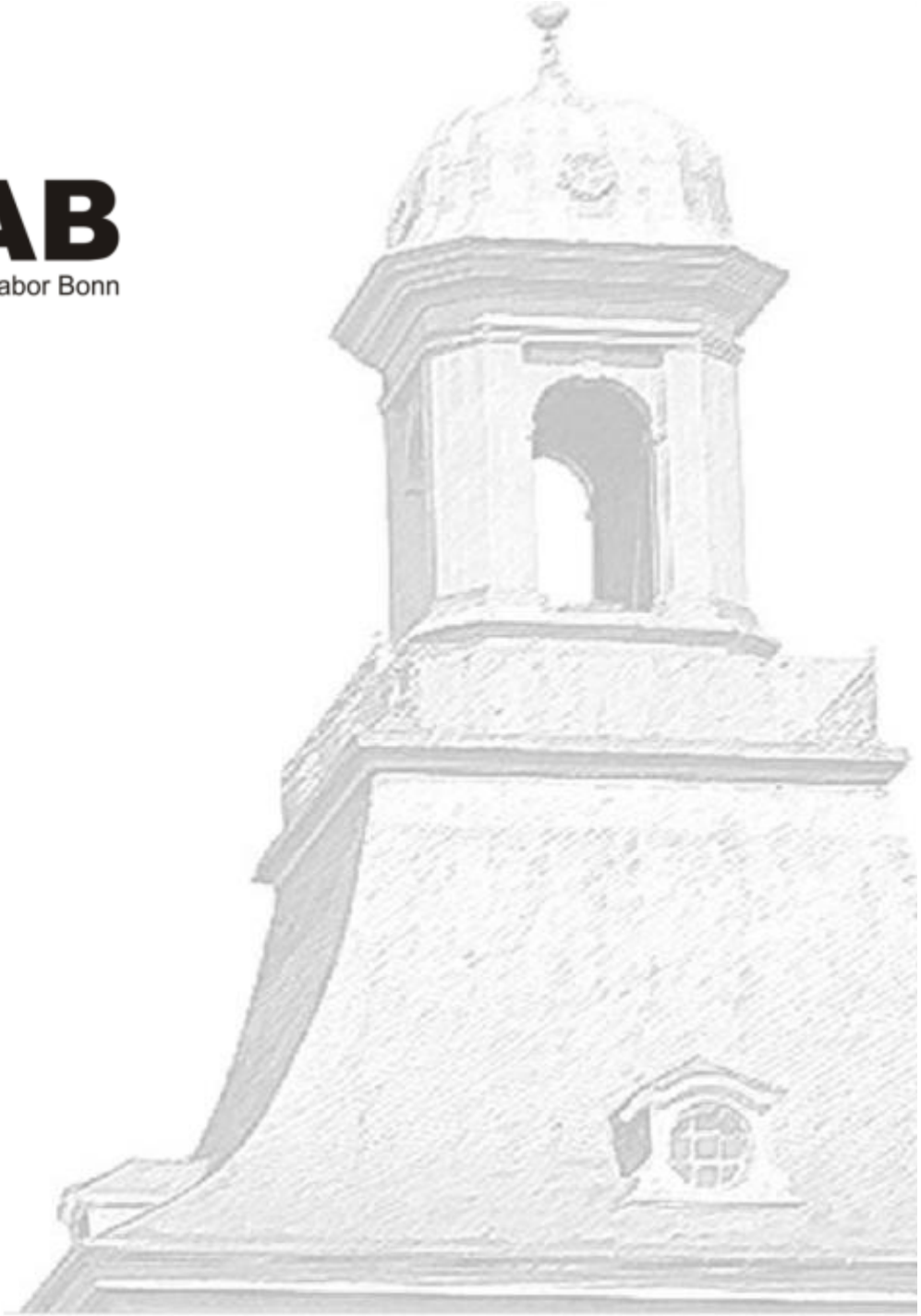

Thank you

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